

Teachers' Use of Educational Technology and Web Adventures: Innovative Interactive Digital Media for Learning Science

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Abstract: Technology is a fundamental tool for teaching and learning science. It is a key enabler of continuous, lifelong learning, serving as a gateway to directly accessing knowledge and fostering learning. This paper presents what education technology tools STEM teachers often utilize in their classrooms in general and how they utilize Web Adventures—innovative interactive digital media to inspire and educate middle and high school students in STEM. More than 300 teachers responded to a survey about their technology use in general and Web Adventures use, in particular, in their instruction. Teachers reported high use of learning management systems, educational videos, and online games. Less or rare use of programming languages and interactive devices were reported. Teachers also provided their perceptions on the helpful gamification features for digital educational games. Teachers perceived Web Adventures games effective and useful and found their online or printable instructional materials as of high quality. This input from the field has implications for developers of education technology, school administrators and other stakeholders for appropriate selection of technologies and to develop effective online games to teach STEM subjects effectively.

Introduction

Technology has been so intertwined with human life and is now an integral part to it. It is similarly becoming even more eminent and widespread than ever in science classrooms. Moreover, recent unprecedented developments due to the COVID-19 pandemic have pushed the education world into virtual space, making it clear that educational technology is indispensable. This change, of course, has implications for teachers: the expectation is that science, technology, engineering, and mathematics (STEM) teachers' everyday teaching practices should change in a way that integrates technology into teaching STEM subjects. With appropriate use, instructional technology can help teachers enact their teaching-related tasks more effectively, and in turn, facilitate students' learning of STEM subjects. Emerging technologies in schools have the potential to transform learning and teaching of school science and mathematics (e.g., International Society for Technology in Education, 2007).

This shift in practice, coming in an exponential speed, however, may bring technology pollution into schools as much as it brings its affordances. Today, we have an abundance of digital learning resources readily available; however, the problem arises with not knowing where to begin to find the right ones. Today's educators must first narrow the options available to the learner—while assessing quality and standards—and then make an effective selection for instruction. This task is daunting for teachers. Therefore, there are critical antecedents to the development process of any instructional or educative digital media or resources. We first need to understand teachers' and students' needs; align digital resources with the curriculum, pedagogical methods, and assessment; and identify the barriers to access technology (Leones et al., 2021). Moreover, support materials surrounding an interactive digital media activity or digital games are essential to its utility for instruction and learning, no matter whether it is intended for formal in-class instruction, extracurricular activity, or other informal learning (Becker & Gopin, 2016).

In this current context, researchers are charged with two important tasks: to understand what technologies teachers often use and what educator tools and gamification or interactive features they need the most in digital materials, especially the interactive ones, for an effective student learning experience. Can be considered as a needs-assessment, this practitioner perspective will help researchers, teacher educators, and technology developers understand and provide the most effective and efficient technology resources to teachers and students.

This paper presents STEM teachers' use of technology addressing the two tasks presented above and a specific case in technology use: Web Adventures—interactive digital media using serious games frameworks.

Literature

There is a gradually growing acceptance of the use of interactive digital media (IDM) for learning, particularly, of games designed specifically for learning (a.k.a. “serious games,” Dimitra et al., 2020). In serious games, the educational purpose of the game is explicit and part of the design goals right from the beginning. Though historical skepticism for games in education is well established, there is strong evidence that the use of games for learning holds sufficient promise to warrant continued inquiry (Perrotta et al., 2013). Especially during the COVID-19 pandemic, digital resources became extremely critical. Perceptions of and ways of using digital resources have dramatically shifted in directions that increase the acceptance and use of digital resources (Dimitra et al., 2020). Virtual tools and interactive digital media became the core of everyday instruction during these unprecedented times. It is, thus, crucial to investigate the most effective components of digital resources that improve student learning and motivation beyond previous in-class paradigms.

Interactive Digital Media (IDM) and Games

Beyond the engaging and stimulating aspects of gaming, improvement in areas such as communication, problem-solving, and numeric tasks often occur because of well-designed games (McFarlane et al., 2002; Monroy et al., 2011). However, there are very real constraints that developers face when designing IDM for the science classroom, including curriculum alignment, which is a crucial element in IDM development for educational purposes. In this era of high-stakes testing, most teachers will introduce or use IDM only when they are well-aligned with a mandated curriculum. While it is true that each state is free to adopt its own scope and sequence of science content, most states' curricula adhere to National Science Education Standards with slight variations. Teachers need to identify how IDM resources can match their curriculum standards.

Research on the use of interactive digital media indicates increased student motivation (psychological aspect) and learning (cognitive aspect) in science (e.g., Beier et al., 2012; Bowling et al., 2013). In support of game-based learning, Foster (2008) noted that “serious” games (games for learning, not for entertainment) have the “capability to make science personally valued, concrete, and applicable to students' lives, as well as foster changes in possible selves.” The theory of possible selves (Markus & Nurius, 1986) provides some insight into how the “gamification” of virtual science and health IDM and career experiences may make a difference. The WA—Cool Science Careers series, for example, is a transformative tool for science career inspirations and positive changes in possible selves (Miller, 2005). Each player explores aspects of one's identity and becomes motivated to learn (even if unconsciously so) via relevant experiences and/or scenarios provided by “serious,” educative, and structured online gameplay.

Web Adventures

Web Adventures (WA) is a set of online educational games for middle and high school students to learn about health and science and to inspire them to pursue careers in STEM. Originally developed by Rice University's Center for Technology in Teaching and Learning (CTTL), WA offers more than 30 free educational game sessions/activities under five main titles (with Spanish and German versions for the most popular titles). Students learn about forensics, science careers, microbiology, neuroscience, and drug and alcohol abuse through WA games. Numerous studies specifically conducted on WA indicated positive impact of these games on students' science motivation and knowledge. Over the years, WA games served millions of students and teachers across the globe. Since Flash, the technology games were created in, became obsolete in 2021, a system for offline playing capability for games was created in response to the outcry from the global community during the pandemic when online tools became vital to education. Other supplemental resources, such as cool links and teacher guides are updated and still available online. The archival game site extends the window of access to the old games until the games are redeveloped in new technologies.

Participants

More than 300 teachers were surveyed about their use of technology, needs in technology use, and their use of Web Adventures, specifically. Teachers' subject areas were science (47%), mathematics (8%), technology and engineering (20%), and other subjects (25%). Regarding the school level, 5% pre-school, 10% elementary, 35% middle school, and 50% high school teachers participated. Seven percent taught fewer than six years; 16% taught six to 10 years; and 77% taught 11 years or more.

Results

Descriptive results indicated learning management systems (Google Classroom, Schoology, Canvas, etc.) and Office applications (Word processors, presentation programs, etc.) were among most often used technology tools teachers used. Other frequently used technologies included online educational videos (podcasts, TED talks etc.), digital learning tools (ClassDojo, Kahoot, Whiteboard.fi etc.), online games, and in-app API integrations (Quizlet Flashcards API, Khan Academy API, Zoom, Blackboard, etc.). Some teachers also reported use of iPads/Chromebooks, GIS tools, robotics tools, and video editing software. Programming languages (C++, Java,

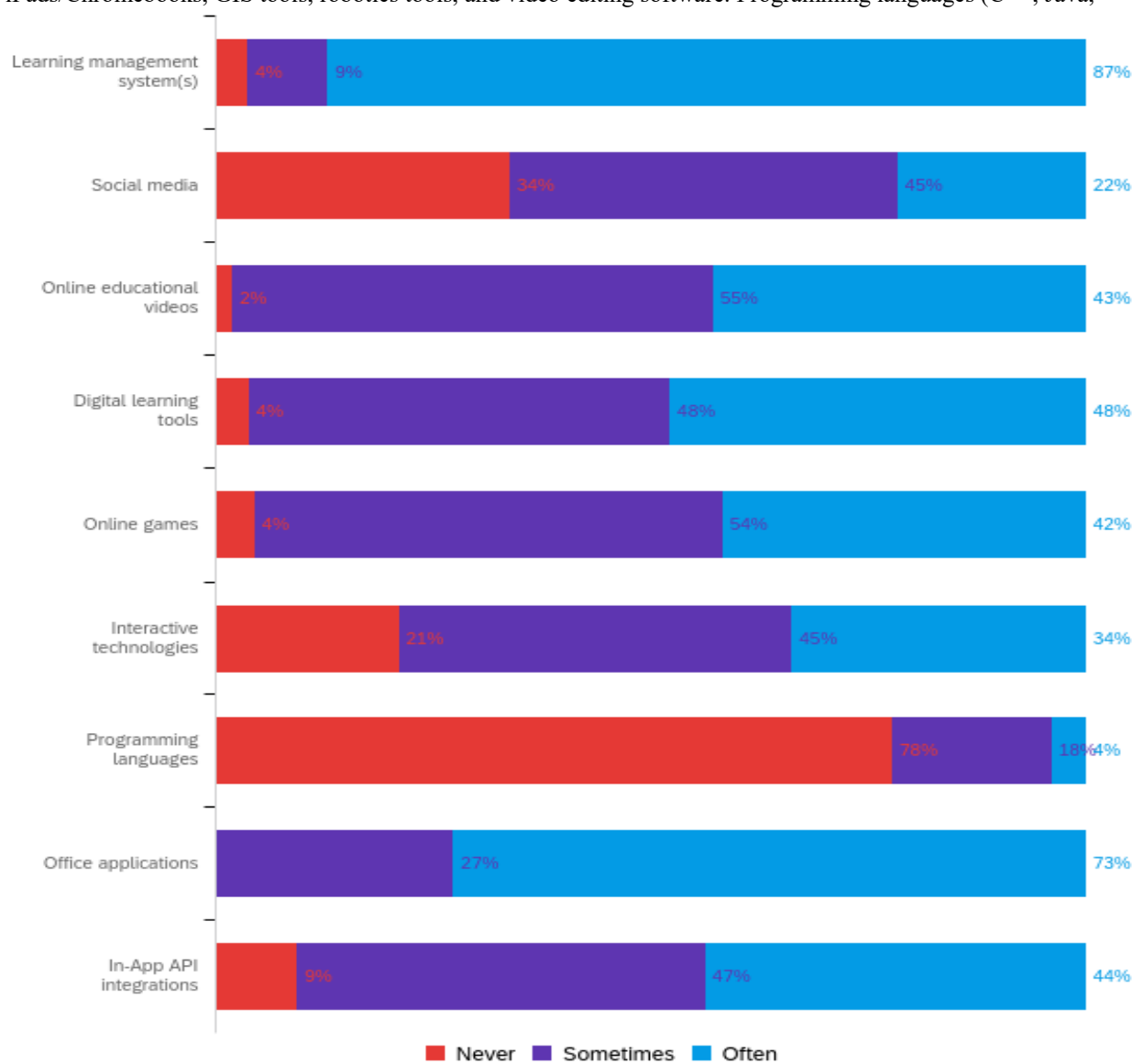


Figure 1. Frequency in the Use of Different Educational Technology Tools

Python, etc.), social media (blogs, Instagram, FB, Twitter, etc.), and interactive technologies (Clickers, Smartboard, etc.) were never used by a significant portion of teachers. This summarizes general technology tools used by teachers for instructional purposes. Figure 1 depicts the use of these general educational technology tools.

Regarding online educational games in general, teachers valued the following gamification features the most: game progress bar, goals & achievements (badges), game hints (tips), and difficulty levels. Secondarily valued features were: game avatars, game points, rewards (surprises & prizes). Game challenges, certificates, bonus

Features	Percentage of teachers who think the feature is helpful
Game Progress Bar	63%
Goals & Achievements (Badges)	56%
Game Hints (Tips)	50%
Difficulty Levels	49%
Game Avatars	39%
Game Points	39%
Game Challenges	36%
Rewards (Surprises & Prizes)	36%
Certificates	33%
Bonus Content	32%
Leaderboard / Scoreboard	31%
Progress Alerts	27%
Player Customization Settings	26%
Performance Measurement (Gameplay Statistics)	24%
Player Ranking	21%
Student Reviews (Game Rating)	19%
Polls	16%
Student/Student Communication (Chat)	15%
In-App Currency	12%
Game Messaging	12%

Table 1. Teachers' Rating of Helpful Gamification Features

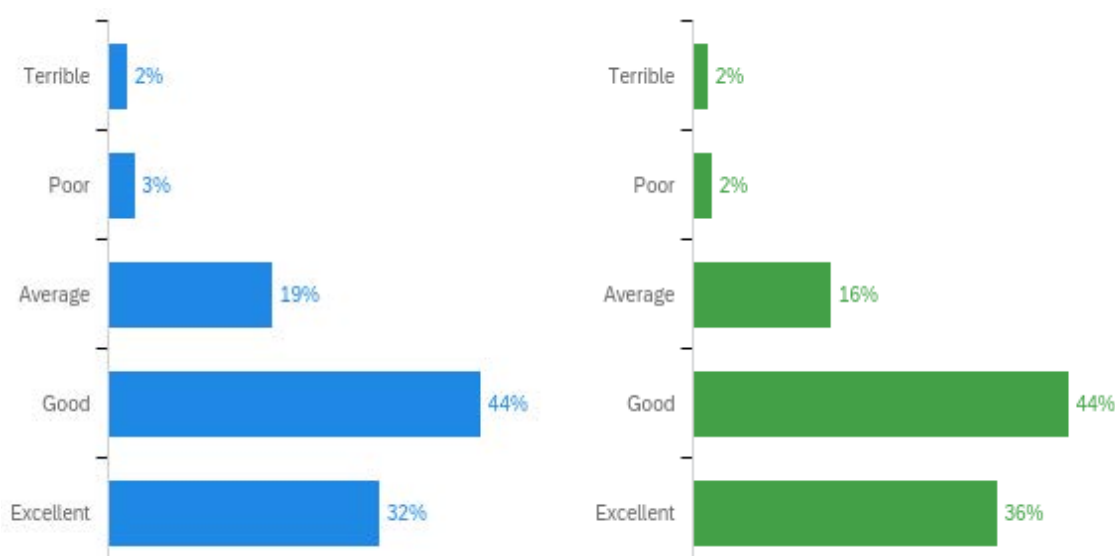


Figure 2. Teachers' rating of Web Adventures Games: Overall Experience (left) and Quality of Instructional Materials (right).

content, leaderboard/scoreboard, player customization settings, progress alerts, and performance measurement (gameplay statistics). Teachers cared the least about the following features: player ranking, student reviews (game rating), polls, student/student communication (chat), and in-app currency, game messaging. Table 1 summarizes the how much value teachers placed on different gamification features.

Regarding Web Adventures, among teachers who used these specific educational games before, 76% rated them as good or above; 19 % gave an average rating; and 5% thought Web Adventures were poorly designed. Regarding their supplemental educational materials 79% of teachers found them very useful, 16% found somewhat useful; and 4% did not find them useful at all. Figure 2 presents the teachers' rating about Web Adventures games. One fourth of teachers used Web Adventures for less than a year (new users); around 30% used one- to-3 years; and more than 45% used them more than three years. More than 40% of teachers utilized more than one game title (each title has three- to-seven games/activities) but the mostly used one is the CSI: The Experience (see Figure 3).

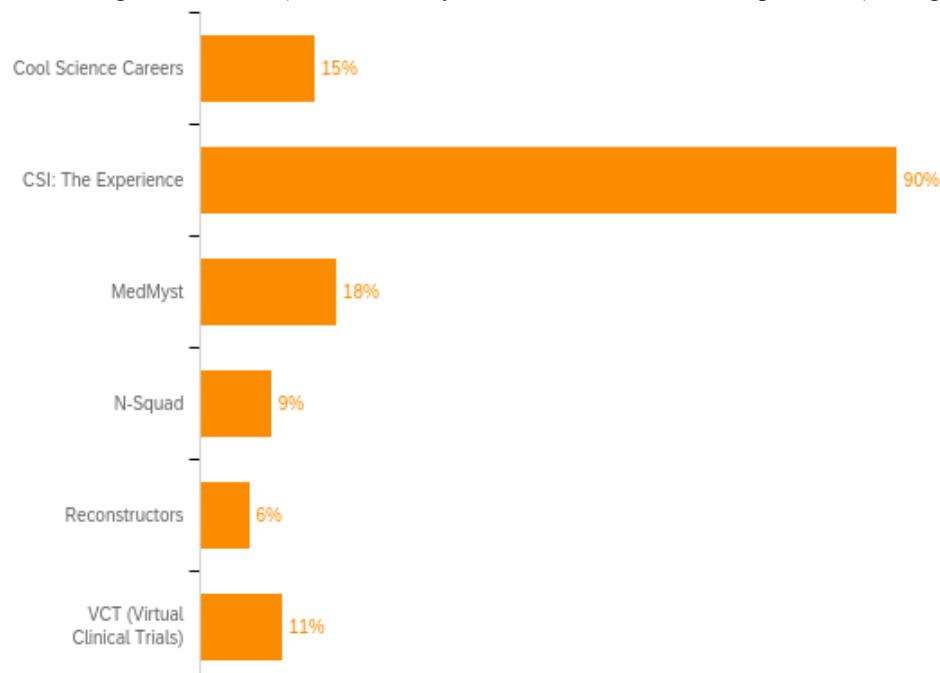


Figure 3. Use of Web Adventures Games by Game Title.

Discussion

These results will be useful for teacher educators and school administrator to decide what technology supports they should provide to their teachers. It is apparent that most schools and teachers made their way into leveraging several online technologies. The fact that learning management systems are the most frequently used tools is not surprising. On the other hand, there are handful of teachers who reported on use of these technologies. Further studies need to understand if this by choice or due to inadequate resources. Regarding other frequently used technologies, researchers and educators caution teachers about use of online resources (educational videos, online games, or other digital learning tools like Kahoot) by students especially during instructional time, because providing such platforms opens doors to off-task use of other online tools, and therefore, needs a controlled environment (e.g., Zirawage et al., 2017).

Less use of programming languages and interactive technologies such and clickers and smartboards is alarming given the importance of computer science and recent push for its integration into K12 curriculum (e.g., Vegas & Fowler, 2020) and the affordances of interactive digital tools (e.g., Lawrance et al., 2020). Perhaps, teachers need effective professional development in learning how to effectively integrate these technologies into their instruction. Similarly, teacher education program need to provide effective training for their prospective student teachers.

Regarding teachers' perceptions about gamification features, which can be naturally embedded not only into online or digital games but also into any digital learning activity, most useful features found by teachers provide

important information for developers of such tools and teacher educators. These features are in alignment with and provide opportunities for active learning theories (e.g., Swiderski, 2011).

Lastly, teachers' uses of Web Adventures games reflected positive views on these games. The fact that they found these games (as well as their accompanying instructional materials and repositories for external related resources) of good quality supports the need of continuation of these games for student learning, motivation, and persistence in STEM fields (as indicated by prior research; e.g., Beier et al., 2012).

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